Claims:

1. A composition of matter prepared in accordance with a method comprising the steps of:

(a) combining a substance selected from the group consisting of: metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, with a source of hydrogen, to form a first intermediate;

(b) milling the first intermediate to effect reaction between the substance and the hydrogen to form a second intermediate;

(c) combining the second intermediate with a source of an electronegative element, to form a third intermediate; and

(d) milling the third intermediate to effect reaction between the second intermediate and the electronegative element.

2. The composition as claimed in claim 1, wherein each of steps (a) and (c) is conducted in a substantially inert gaseous environment.

3. The composition as claimed in claim 2, wherein step (a) is carried out in a gaseous environment having an insufficient concentration of an oxidizing agent to effect deleterious oxidation of the metal or metalloid component, or the alloy thereof, or the homogeneous or inhomogeneous combination of at least two of the metal or metalloid.

4. The composition as claimed in claim 3, wherein step (c) is carried out in a gaseous environment having an insufficient concentration of a reducing agent to effect deleterious reduction of the intermediate product.

5. The composition as claimed in any of claims 1, 2, 3 or 4, wherein the metal or metalloid is selected from the group consisting of Li, Na, K, Be, Mg, Ca, Y, Sc, Ti, Zr, Hf, V, Nb, Ta, Pt, Pd, Ru, Rh, Ge, Ga, In, La, Ce, Pr, Nd, Dy, Al, Si, B, Cr, Mo, W, Mn, Fe, Co, Ir, Ni, Cu, Ag, Au, Zn, Sn, Pb, Sb, and Bi .

6. The composition as claimed in claim 5, wherein the electronegative element is selected from the group consisting of O, F, N, Cl, S, P, C, Te, and I.

7. The composition as claimed in claim 6, having a particulate form consisting of a plurality of particles, and having a particle size of less than 100 microns.

8. The composition as claimed in claim 7, wherein at least 80% of the particles have a particle size of less than 50 microns.

9. The composition as claimed in claim 8, wherein the particles include a plurality of grains and the size of each of the plurality of grains is less than 100 nm.

10. The composition as claimed in claim 6, having an X-ray diffraction pattern that exhibits a characteristic Bragg's reflection of a co-ordination of (i) metal or metalloid and (ii) hydrogen.

11. The composition as claimed in claim 10, wherein the milling of each of steps (a) and (c) is carried out in a high energy ball mill.

12. The composition as claimed in claim 10, wherein the milling in each of steps (a) and (c) imparts an impact energy sufficient to effect the reactions of each of steps (a) and (c).

13. A composition of matter prepared in accordance with a method comprising:

(a) combining (i) a metallic substance selected from the group consisting of a hydrogenated, metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the hydrogenated, metal or metalloid, or the alloy thereof, or the compound thereof, with (ii) a source of an electronegative element, to form a first intermediate; and

(b) milling the first intermediate to effect reaction between the metallic substance and the electronegative element.

14. The composition as claimed in claim 13, wherein the milling is carried out in a substantially inert environment.

15. The composition as claimed in claim 14, wherein the milling is carried out in a gaseous environment having an insufficient concentration of a reducing agent to effect deleterious reduction of the intermediate product.

16. The composition as claimed in any of claim 13, 14, or 15, wherein the metal or metalloid component is selected from the group consisting of Li, Na, K, Be, Mg, Ca, Y, Sc, Ti, Zr, Hf, V, Nb, Ta, Pt, Pd, Ru, Rh, Ge, Ga, In, La, Ce, Pr, Nd, Dy, Al, Si, B, Cr, Mo, W, Mn, Fe, Co, Ir, Ni, Cu, Ag, Au, Zn, Sn, Pb, Sb, Bi.

17. The composition as claimed in claim 16, wherein the electronegative element is selected from the group consisting of O, F, N, Cl, S, P, C, Te and I.

18. The composition as claimed in claim 17, having a particulate form, and having a particle size of less than 100 micrometres.

19. The composition as claimed in claim 18, wherein at least 80% of the particles have a particle size of less than 50 microns.

20. The composition as claimed in claim 19, wherein the particles include a plurality of grains and the size of each of the plurality of grains is less than 100 nm.

21. The composition as claimed in claim 17, having an X-ray diffraction pattern that exhibits a characteristic Bragg's reflection of a co-ordination of (i) metal or metalloid and (ii) hydrogen.

22. The composition as claimed in claim 21, wherein the source of the electronegative element is a metal oxide.

23. The composition as claimed in any of claim 22, wherein the milling imparts an impact energy sufficient to effect the reaction.

24. The composition as claimed in claim 23, wherein the milling is carried out in a high energy ball mill.

25. A composition of matter prepared in accordance with a method comprising the steps of:

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(c) effecting a reaction between (i) a metallic substance selected from the group consisting of a metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) hydrogen, by a first milling, to form an intermediate product; and

(d) effecting a reaction between the intermediate product and an electronegative element, by a second milling.

26. The composition as claimed in claim 25, wherein each of steps (a) and (b) is conducted in a substantially inert gaseous environment.

27. The composition as claimed in claim 26, wherein step (a) is carried out in a gaseous environment having an insufficient concentration of an oxidizing agent to effect deleterious oxidation of the metal or metalloid, or the alloy thereof, or the homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof.

28. The composition as claimed in claim 27, wherein step (b) is carried out in a gaseous environment having an insufficient concentration of a reducing agent to effect deleterious reduction of the intermediate product.

29. The composition as claimed in any of claims 25, 26, 27, or 28, wherein the metal or metalloid is selected from the group consisting of Li, Na, K, Be, Mg, Ca, Y, Sc, Ti, Zr, Hf, V, Nb, Ta, Pt, Pd, Ru, Rh, Ge, Ga, In, La, Ce, Pr, Nd, Dy, Al, Si, B, Cr, Mo, W, Mn, Fe, Co, Ir, Ni, Cu, Ag, Au, Zn, Sn, Pb, Sb, Bi.

30. The composition as claimed in claim 29, wherein the electronegative element is selected from the group consisting of O, F, N, Cl, S, P, C, Te, and I.

31. The composition as claimed in claim 30, having a particulate form, and having a particle size of less than 100 microns.

32. The composition as claimed in claim 31, wherein at least 80% of the particles have a particle size of less than 50 microns.

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33. The composition as claimed in claim 32, wherein the particles include a plurality of grains and the size of each of the plurality of grains is less than 100 nm.

34. The composition as claimed in claim 30, having an X-ray diffraction pattern that exhibits a characteristic Bragg's reflection of a co-ordination of (i) metal or metalloid and (ii) hydrogen.

35. The composition as claimed in any of claim 34, wherein each of the first milling of step (a) and the second milling of step(b) imparts an impact energy sufficient to effect the respective reactions of steps (a) and (b).

36. The composition as claimed in claim 35, wherein the first milling and the second milling is carried out in a high energy ball mill.

37. A composition of matter prepared in accordance with a method comprising:

effecting reaction between (i) a metallic substance selected from the group consisting of: hydrogenated, metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous on inhomogeneous combination of at least two of the hydrogenated, metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) an electronegative element, by milling.

38. The composition as claimed in claim 37, wherein the milling is carried out in a substantially inert environment.

39. The composition as claimed in claim 38, wherein the milling is carried out in a gaseous environment having an insufficient concentration of a reducing agent to effect deleterious reduction of the intermediate product.

40. The composition as claimed in any of claim 37, 38, or 39, wherein the metal or metalloid is selected from the group consisting of Li, Na, K, Be, Mg, Ca, Y, Sc, Ti, Zr, Hf, V, Nb, Ta, Pt, Pd, Ru, Rh, Ge, Ga, In, La, Ce, Pr, Nd, Dy, Al, Si, B, Cr, Mo, W, Mn, Fe, Co, Ir, Ni, Cu, Ag, Au, Zn, Sn, Pb, Sb, Bi.

41. The composition as claimed in claim 40, wherein the electronegative element is selected from the group consisting of O, F, N, Cl, S, P, C, Te and I.

42. The composition as claimed in claim 41, having a particulate form, and having a particle size of less than 100 microns.

43. The composition as claimed in claim 42, wherein at least 80% of the particles have a particle size of less than 50 microns.

44. The composition as claimed in claim 43, wherein the particles include a plurality of grains and the size of each of the plurality of grains is less than 100 nm.

45. The composition as claimed in claim 41, having an X-ray diffraction pattern that exhibits a characteristic Bragg's reflection of a co-ordination of (i) metal or metalloid and (ii) hydrogen.

46. The composition as claimed in claim 45, wherein the source of the electronegative element is a metal oxide.

47. The composition as claimed in any of claim 46, wherein the milling imparts an impact energy sufficient to effect the reaction.

48. The composition as claimed in claim 47, wherein the milling is carried out in a high energy ball mill.

49. A composition of matter prepared in accordance with a method comprising:

(a) combining a metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof, with a liquid selected from the group consisting of water and alcohols and mixtures thereof, to form a first intermediate; and

(b) milling the first intermediate.

50. The composition as claimed in claim 49, wherein the milling is carried out in a substantially inert environment.

51. The composition as claimed in any of claim 50 or 51, wherein the metal or metalloid component is selected from the group consisting of Li, Na, K, Be, Mg, Ca,

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Y, Sc, Ti, Zr, Hf, V, Nb, Ta, Pt, Pd, Ru, Rh, Ge, Ga, In, La, Ce, Pr, Nd, Dy, Al, Si, B, Cr, Mo, W, Mn, Fe, Co, Ir, Ni, Cu, Ag, Au, Zn, Sn, Pb, Sb, Bi.

52. The composition as claimed in claim 51, wherein the molar ratio of the liquid to the metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof, is less than about 1:1.

53. The composition as claimed in claim 52, having a particulate form, and having a particle size of less than 100 microns.

54. The composition as claimed in claim 53, wherein at least 80% of the particles have a particle size of less than 50 microns.

55. The composition as claimed in claim 54, wherein the particles include a plurality of grains and the size of each of the plurality of grains is less than 100 nm.

56. The composition as claimed in claim 53, having an X-ray diffraction pattern that exhibits a characteristic Bragg's reflection of a co-ordination of (i) metal or metalloid and (ii) hydrogen.

57. The composition as claimed in any of claim 56, wherein the milling imparts an impact energy sufficient to effect the reaction.

58. The composition as claimed in claim 57, wherein the milling is carried out in a high energy ball mill.

59. A hydrogen storage composition prepared in accordance with a method comprising the steps of:

(a) effecting a reaction between (i) a first metallic substance selected from the group consisting of: metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) hydrogen, by a first milling, to form an intermediate product; and

(b) effecting a reaction between the intermediate product and an electronegative element, by a second milling, to form a hydrogen transfer facilitator; and

(c) combining the hydrogen transfer facilitator with a second metallic substance selected from the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, such combining effecting sufficient contact between the hydrogen transfer facilitator and the second metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the second metallic substance.

60. The hydrogen storage composition as claimed in 59, wherein the hydrogen transfer facilitator is mechanically alloyed to the second metallic substance.

61. The hydrogen storage composition as claimed in 60, wherein the mechanical alloying is effected by a third milling.

62. A hydrogen storage composition prepared in accordance with a method comprising the steps of:

(a) effecting reaction between (i) a first metallic substance selected from the group consisting of: hydrogenated, metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous on inhomogeneous combination of at least two of the hydrogenated, metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) an electronegative element, by milling, to form a hydrogen transfer facilitator; and

(b) combining the hydrogen transfer facilitator with a second metallic substance selected from the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, such combining effecting sufficient contact

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between the hydrogen transfer facilitator and the second metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the second metallic substance.

63. The hydrogen storage composition as claimed in 62, wherein the hydrogen transfer facilitator is mechanically alloyed to the second metallic substance.

64. The hydrogen storage composition as claimed in 63, wherein the mechanical alloying is effected by a third milling.

65. A process of hydrogenating and dehydrogenating a hydrogen storage composition comprising the steps of:

(a) effecting absorption of hydrogen by the hydrogen storage composition; and

(b) effecting desorption of the absorbed hydrogen from the hydrogen storage composition; wherein steps (a) and (b) are carried out in any order;

and wherein the hydrogen storage composition is prepared by combining a metallic substance selected form the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, with a hydrogen transfer facilitator, such combining effecting sufficient contact between the hydrogen transfer facilitator and the second metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the metallic substance,

and wherein the hydrogen transfer facilitator is prepared in accordance with a method selected from a group consisting of a first method and a second method,

wherein the first method comprising the steps of:

(a) effecting a reaction between (i) a first metallic substance selected from the group consisting of: metal or metalloid, or an alloy thereof, or a compound thereof, or

an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) hydrogen, by a first milling, to form an intermediate product; and

(b) effecting a reaction between the intermediate product and an electronegative element, by a second milling;

and wherein the second method comprises the steps of effecting reaction between (i) a first metallic substance selected from the group consisting of: hydrogenated, metal or metalloid, or an alloy thereof, or a compound thereof, or an homogeneous on inhomogeneous combination of at least two of the hydrogenated, metal or metalloid, or the alloy thereof, or the compound thereof, and (ii) an electronegative element, by milling.

66. A hydrogen storage composition comprising:

a metallic substance selected from the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof; and

a hydrogen transfer facilitator having an atomic co-ordination characterized by one of the following structural formula:

(a) (M+M1)-H--E

or

(b) (M)-H--E

wherein the hydrogen transfer facilitator is disposed in sufficient contact with the metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the second metallic substance.

67. A hydrogen storage composition comprising:

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a metallic substance selected from the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof; and

a hydrogen transfer facilitator having an atomic characterization characterized with the following structural formula:

M - - H – E

wherein the hydrogen transfer facilitator is disposed in sufficient contact with the metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the second metallic substance.

68. A hydrogen storage composition comprising:

a metallic substance selected from the group consisting of: (a) a hydride of a metal or metalloid, or an alloy thereof, or a compound thereof, or a homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof, or (b) a metal or metalloid capable of absorbing hydrogen to form a hydride, or an alloy thereof, or a compound thereof, or an homogeneous or inhomogeneous combination of at least two of the metal or metalloid, the alloy thereof, or the compound thereof; and

a hydrogen transfer facilitator having an atomic characterization characterized with the following structural formula:

M – H - - H

wherein the hydrogen transfer facilitator is disposed in sufficient contact with the metallic substance so that the hydrogen transfer facilitator is configured to effect absorption or desorption of hydrogen by the second metallic substance.

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